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(12) # EUROPEAN PATENT APPLICATION

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(54) **Investment casting process and mould.**

(57) In the investment casting of hollow parts in a shell mould or in a block mould a slender core (2) is supported by means of chaplets (7) in an outer mould part (1). The chaplets are made of expanded metal and are preferably bent to form a 'C', 'V' or 'U' shaped cross section. This form of chaplet provides for good support whilst promoting diffusion thereof during the casting of the molten metal in the mould.

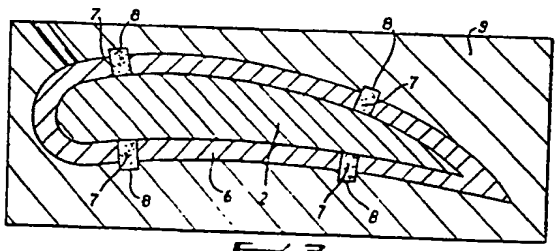

FIG 3

EP 0 084 234 A1

INVESTMENT CASTING PROCESS AND MOULD

The present invention relates to a method of investment casting and to an investment casting mould.

The invention specifically concerns a mould comprising an outer part surrounding an inner core. This type of mould is well known and is used for the casting of hollow parts such as, for example, turbine blades and guide vanes for jet propulsion engines. The core is usually held in position at its extremities within the outer part of the mould by means of supports known as prints extending between the outer part and the core. If the cores are very slender, further supports at intermediate positions may be necessary. These supports are called chaplets and their construction and method of insertion into the mould affects not only the moulding process itself but also the finished moulded article. Such chaplets, more usually constructed of two discs joined by a cylinder, have been extensively used in sand casting moulds for many years.

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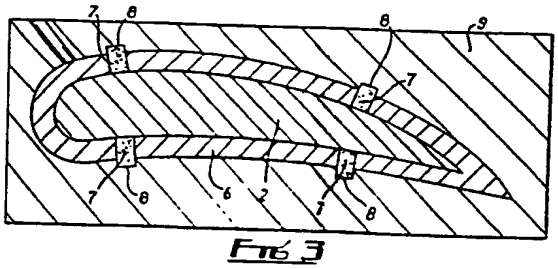

Fig 3

EP 0 084 234 A1

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An existing form of chaplets as used in shell moulds consists of a pin or wire. In the pattern making process, after forming a wax pattern about a ceramic core, by placing the core in the wax pattern die and injecting wax into it, the pin or wire form chaplet is pushed into the wax until it contacts the core. The length of the pins or wires is chosen so that they project slightly from the wax after insertion and locate in the outer part of the mould which is subsequently formed about them. An advantage of the pin or wire chaplet over the earlier disc/cylinder chaplet is that the reduced bulk of the chaplet promotes its fusion with the poured metal during casting.

According to one aspect of the present invention there is provided a method of investment casting using an investment casting block mould having a core including the steps of forming a pattern about the core of the mould, inserting the chaplets into the pattern until they engage the core, forming the outer part of the mould about the pattern, removing the pattern, pouring molten metal into the cavity left thereby to produce a casting into which the material of the chaplets is fused, allowing the molten

metal to solidify and removing the outer part and core of the block mould.

According to another aspect of the present invention, there is provided a method of investment casting using an investment casting mould having a core including the steps of forming a pattern about the core of the mould, forming chaplets from sheets of expanded metal, inserting the chaplets into the pattern until they engage the core, forming the outer part of the mould about the pattern, removing the pattern, pouring molten metal into the cavity left thereby to produce a casting into which the material of the expanded metal chaplets is fused, allowing the molten metal to solidify, and removing the outer part and core of the mould.

A preferred embodiment of the method of the invention may comprise one or more of the following advantageous features:-

(a) Each chaplet is dimensioned so that a portion of it projects from the wax pattern and subsequently locates in the outer part of the mould.

(b) Each chaplet is a flat strip of expanded metal.

(c) Each chaplet is bent in the plane of the surface of the pattern.

(d) Each chaplet of (c) is bent to give the chaplet a 'C' shaped cross section.

(e) Each chaplet of (c) is bent to give the chaplet a 'U' shaped cross section.

(f) Each chaplet of (c) is bent to give the chaplet a 'V' shaped cross section.

(g) Each chaplet is made of platinum, or combinations of nickel cobalt and chromium alloys, or such dense metal alloys coated with platinum or other metal of superior oxidation resistance.

(h) The pattern is made of wax, synthetic plastics or other material having a relatively low melting point.

(i) The core and mould outer part are made of a ceramic material.

(j) Each chaplet is heated to a temperature above the melting point of the pattern material to ease its passage through the pattern.

According to a further aspect of the invention, there is provided an investment casting block mould comprising a core, a mould outer part disposed around and spaced from the core and chaplets extending between the outer part and the core and locating the core within the outer mould part.

According to a still further aspect of the invention, there is provided an investment casting mould comprising a core, a mould outer part disposed around and spaced from the core, and chaplets made of expanded metal extending between the outer part and the core and locating the core within the outer mould part.

A preferred embodiment of the mould of the invention may comprise one or more of the following advantageous features:-

(a) The inner part of each chaplet engages but does not penetrate the core and the outer part of each chaplet locates in the outer part of the mould.

(b) Each chaplet is a flat strip of expanded metal.

(c) Each chaplet is bent in the plane of the surface of the mould.

(d) Each bent chaplet of (c) has a 'C' shaped cross section.

(e) Each bent chaplet of (c) has a 'U' shaped cross section.

(f) Each bent chaplet of (c) has a 'V' shaped cross section.

(g) Each chaplet is made of platinum, or combinations of nickel cobalt and chromium alloys, or such dense metal alloys coated with platinum or other metal of superior oxidation resistance.

(h) The pattern is made of wax, synthetic plastics or other material having a relatively low melting point.

(i) The core and mould outer part are made of a ceramic material.

The invention also comprises a casting made by the above defined mould and method.

In order that the invention may be more clearly understood, one embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 diagrammatically illustrates the manner of formation of a wax pattern about a mould core,

Figure 2 diagrammatically illustrates the core of the mould with the wax pattern of Figure 1 formed around it with expanded metal chaplets inserted into the wax,

Figure 3 diagrammatically shows the outer mould part formed about the wax pattern of Figures 1 and 2,

Figur 4 diagrammatically illustrates the mould after the wax has been replaced by the metal of the casting, and

Figure 5 illustrates several forms of expanded metal for the chaplets inserted into the wax pattern of Figure 2.

The steps of the production of a vane casting of hollow airfoil section will now be described with reference to the accompanying drawings. The mould to be used effectively comprises two parts, an outer part 1 and a core 2. The core, which is made of ceramic and has an external surface complementary in form to the desired form of the internal surface of the vane, is placed in a pattern die. This is a metal die 3 normally made in several parts and internally machined in complementary fashion to the desired form of the outer surface of the casting to be produced. The core is supported in the die by means of prints 5 which extend from the extremities of the core. The material for making the pattern 6, normally a low melting point substance such as wax or synthetic plastics alternative such as polystyrene, is then injected into the die and allowed to solidify (Figure 1). Thereafter, the die is opened

leaving the ceramic core 2 with the pattern 6 formed on it.

Metal chaplets 7 are then inserted into the material of the pattern 6 (Figure 2) until they abutt the surface of the cermic core 2 beneath leaving portions 8 thereof projecting from the pattern 6. The metal from which the chaplet is constructed must have good resistance to oxidation in mould firing furnace atmospheres. Examples of such metals are, platinum, combinations of nickel cobalt and chromium alloys, or such dense metal alloys coated with platinum or other metal of superior oxidation resistance. To facilitate the passage of the chaplet 7 into the material, each chaplet is usually heated to a temperature above the melting point of the pattern material. Each chaplet 7 is made of expanded metal sheet and several examples of expanded metal sheet felt to be suitable are illustrated in Figure 5.

These particular examples of expanded metal sheet are made by Expamet Industrial Products Limited of 16 Caxton Street, London, SW1H ORA. The expanded metal is made by producing a plurality of slits in a metal sheet and then stretching the sheet to form a mesh. For a given volume of material, a chaplet

made of this material affords a more rigid support distributed over a greater area than a single un-expanded piece of material. This enables less material to be used for a given support requirement, a factor of considerable importance when the chaplets are made of a precious metal such as platinum. The expanded metal may be bent in the plane of the surface of the pattern to form a chaplet of 'C' shaped, 'U' shaped, 'V' shaped or other cross-section thereby enabling support to be produced over a greater area with a single chaplet than would otherwise be the case. In a preferred form each chaplet 7 consists of a sheet of expanded metal having cross-sectional dimensions of approximately 0.015" x 0.040" and a length to enable it to project approximately 0.20" out of the wax pattern to enable ready keying with the mould material of the outer mould part. The apertured nature of the expanded metal material affords ready access to a greater bulk of the material of the chaplet 7 and this promotes fusion of the chaplet with the poured metal in the casting or pouring step itself.

After the required number of expanded metal

chaplets 7 have been inserted in the required positions in the pattern 6, the pattern is dip coated and stuccoed. In this step, an extremely fine ceramic coating, known as a pre-coat, is applied as a slurry directly to the surface of the pattern 6 to reproduce maximum surface smoothness in the casting. The slurry is stuccoed with fine refractory particles and may be made more impermeable to molten metal by the addition of one or even two additional coats. This coated pattern is then surrounded in a block or flask mould by coarser, cheaper and more permeable investment to form the mould. The projecting portions 8 of the chaplets 7 locate in the outer part of the mould 9 so formed (see Figure 3). After the mould material has set and dried the pattern of low melting point material is melted and drained out of the mould which is then heated to a temperature of the order of 1050°C. The molten metal 10 is then poured into the cavity left by the melted pattern. As this molten metal enters the apertures of the expanded metal chaplets, the material of the chaplets 7 is distributed into the mass of the molten material (see Figure 4). After allowing the molten material to

solidify and cool, the outer part of the mould is broken away from the mould and the core 2 of the mould is disolved and removed.

Although the embodiment of the invention described above has been described in relation to the block or flask mould process, expanded metal chaplets may also readily be applied to the shell mould process. In such a process, as compared with the above described block mould process, after the application of the pre-coat for the production of maximum surface smoothness in the casting, several coarser coats are applied, also by dipping and stuccoing, in order to build up a shell strong enough to support the poured metal.

It will be appreciated that the above embodiments have been described by way of example and that many variations are possible within the scope of the invention.

Claims

1. A method of investment casting using an investment casting block mould (1, 2) having a core (2) including the steps of forming a pattern (6) about the core (2) of the mould, inserting the chaplets (7) into the pattern until they engage the core, forming the outer part (1) of the mould about the pattern (6), removing the pattern (6), pouring molten metal (10) into the cavity left thereby to produce a casting into which the material of the chaplets (7) is fused, allowing the molten metal to solidify and removing the outer part (1) and core (2) of the block mould.

2. A method of investment casting using an investment casting mould (1, 2) having a core (2) including the steps of forming a pattern (6) about the core (2) of the mould, forming chaplets (7) from sheets of expanded metal, inserting the chaplets (7) into the pattern (6) until they engage the core(2) forming the outer part (1) of the mould about the pattern (6), removing the pattern (6), pouring molten metal (10) into the cavity left thereby to produce a casting into which the material of the expanded metal chaplets (7) is fused, allowing the

molten metal to solidify, and removing the outer part (1) and core (2) of the mould.

3. A method as claimed in Claim 1 or 2, in which each chaplet (7) is dimensioned so that a portion (8) of it projects from the wax pattern (6) and subsequently locates in the outer part (1) of the mould.

4. A method as claimed in claim 1, 2 or 3, in which each chaplet (7) is a flat strip of expanded metal.

5. A method as claimed in claim 1, 2, or 3, in which each chaplet (7) is bent in the plane of the surface of the pattern.

6. A method as claimed in claim 5, in which each chaplet (7) is bent to give the chaplet a 'C' shaped cross section.

7. A method as claimed in claim 5, in which each chaplet (7) is bent to give the chaplet a 'U' shaped cross section.

8. A method as claimed in claim 5, in which each chaplet (7) is bent to give the chaplet a 'V' shaped cross section.

9. A method as claimed in any preceding claim, in which each chaplet (7) is made of platinum, or combinations of nickel cobalt and chromium alloys, or such dense metal alloys coated with platinum or other metal of superior oxidation resistance.

10. A method as claimed in any preceding claim in which the pattern (6) is made of wax, synthetic plastics or other material having a relatively low melting point.

11. A method as claimed in claim 2 or any of claims 3 to 10 when appendant directly or indirectly to claim 1, in which the outer part (1) of the mould is formed by means of the block or flask mould process.

12. A method as claimed in claim 2 or any of claims 3 to 10 when appendant directly or indirectly to claim 1, in which the outer part (1) of the mould is formed by means of the shell mould process.

13. A method as claimed in any preceding claim, in which the core (2) and mould outer part (1) are made of a ceramic material.

14. A method as claimed in any preceding claim, in

which each chaplet (7) is heated to a temperature above the melting point of the pattern material to ease its passage through the pattern (6).

15. An investment casting block mould comprising a core (2), a mould outer part (1) disposed around and spaced from the core (2) and chaplets (7) extending between the outer part (1) and the core (2) and locating the core (2) within the outer mould part (1).

16. An investment casting mould comprising a core (2), a mould outer part (1) disposed around and spaced from the core (2), and chaplets (7) made of expanded metal extending between the outer part (1) and the core (2) and locating the core (2) within the outer mould part (1).

17. A mould as claimed in claim 15 or 16, in which the inner part of each chaplet (7) engages but does not penetrate the core (2) and the outer part of each chaplet (7) locates in the outer part (1) of the mould.

18. A mould as claimed in claim 15, 16 or 17, in which each chaplet (7) is a flat strip of expanded metal.

19. A mould as claimed in claim 15, 16 or 17, in which each chaplet (7) is bent in the plane of the surface of the mould.

20. A mould as claimed in Claim 19, in which each bent chaplet (7) has a 'C' shaped cross section.

21. A mould as claimed in claim 19, in which each bent chaplet (7) has a 'U' shaped cross section.

22. A mould as claimed in Claim 19, in which each bent chaplet (7) has a 'V' shaped crosssection.

23. A mould as claimed in any of claims 15 to 21, in which each chaplet (7) is made of platinum, or combinations of nickel cobalt and chromium alloys, or such dense metal alloys coated with platinum or other metal of superior oxidation resistance.

24. A mould as claimed in any of claims 15 to 23, in which the pattern (6) is made of wax, synthetic plastics or other material having a relatively low melting point.

25. A mould as claimed in claim 16 or any of claims 17 to 23, when appendant directly or indirectly to claim 16, in which the outer part (1) of the mould is formed by means of the block or flask mould process.

26. A mould as claimed in claim 16 or any of claims 17 to 23 when appendant directly or indirectly to claim 16, in which the outer part (1) of the mould is formed by means of the shell mould process.

27. A mould as claimed in any of claims 15 to 26, in which the core (2) and mould outer part (1) are made of a ceramic material.

28. A casting when made by the method of any of claims 1 to 14.

29. A casting when made by the mould of any of claims 15 to 27.

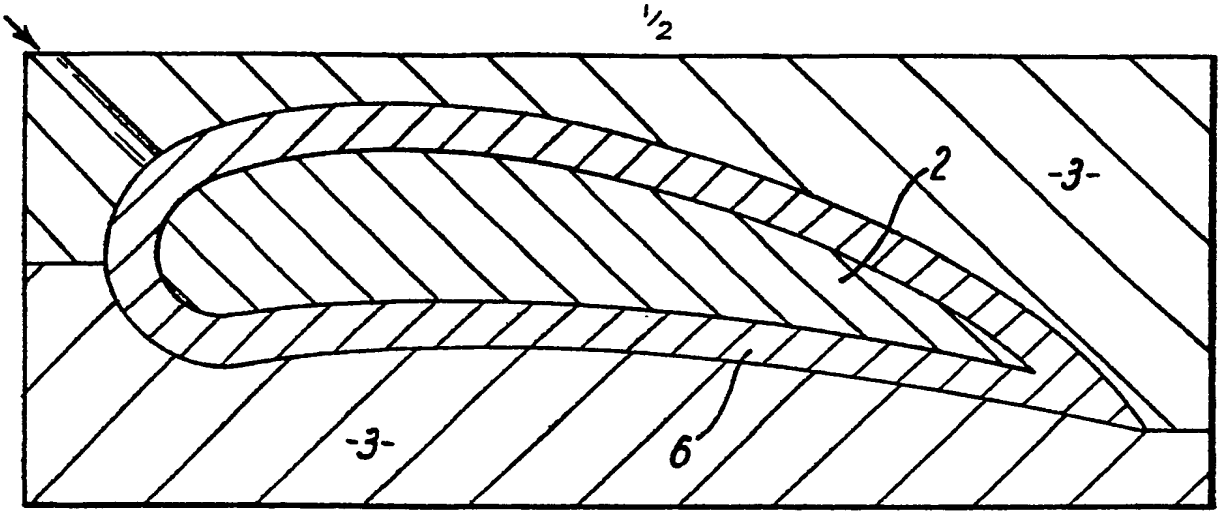

FIG.1

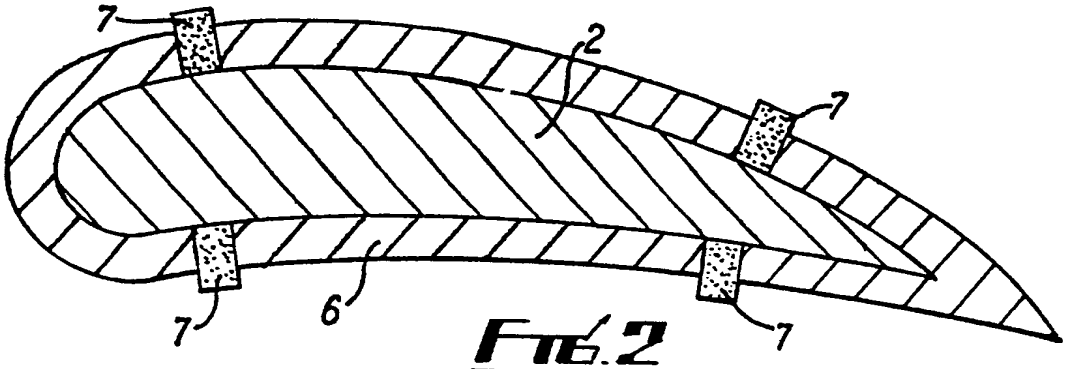

FIG.2

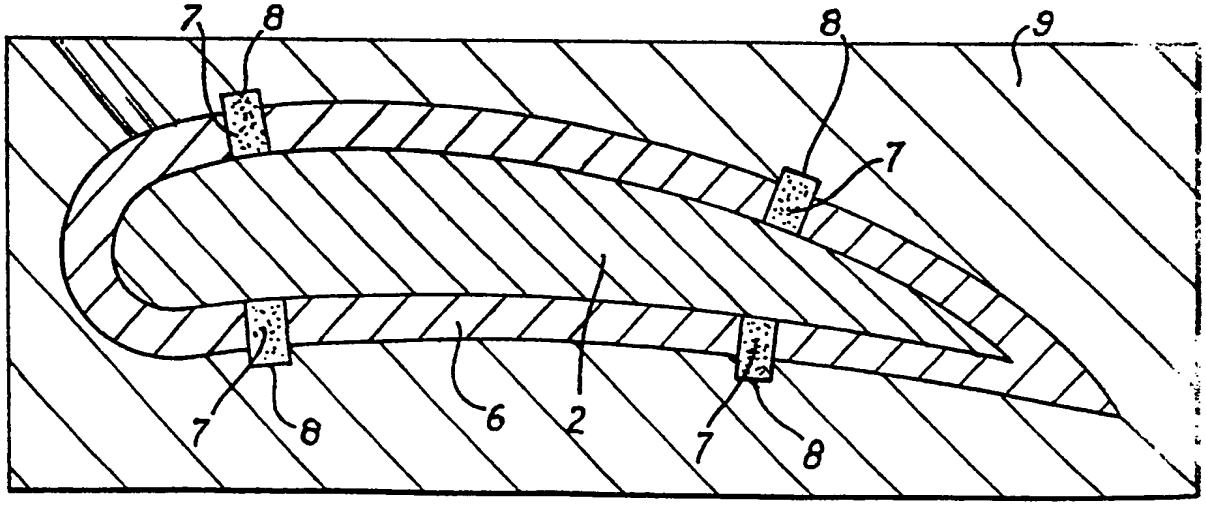

FIG.3

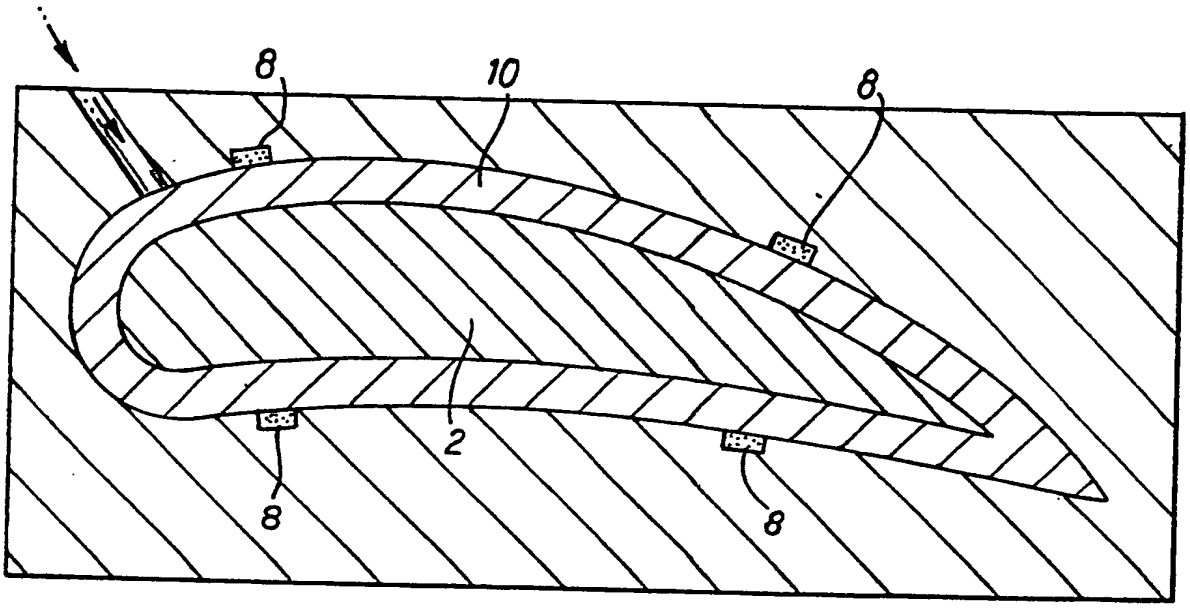

FIG.4

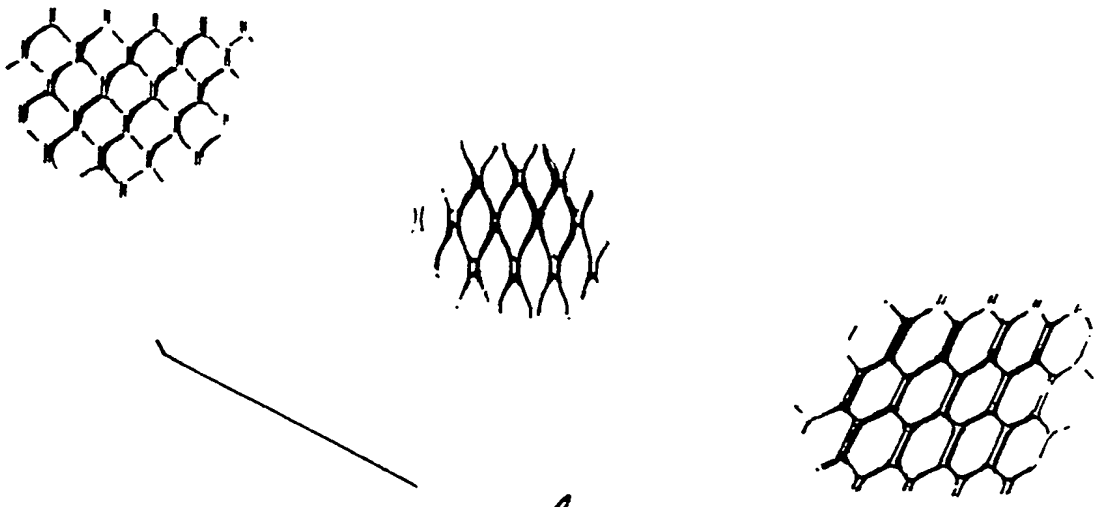

FIG.5

European Patent Office

EUROPEAN SEARCH REPORT

0084234
Application number

EP 82 30 6628

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Y,A	DE-A-2 536 751 (UNITED TECHNOLOGIES CORP.) * Claims 1-15 * ---	1-10	B 22 C 7/02 B 22 C 9/04 B 22 C 9/06 B 22 C 9/24
Y,A	DE-U-1 917 476 (HOWE SOUND CO.) * Claims 1-3 * ---	1-6,15-18	
A	US-A-3 981 344 (HAYES et al.) * Claims 1, 6 * ---	1,16	
A	US-A-4 283 835 (OBROCHTA et al.) * Claims 1, 4 * ---	1,2	
A	GB-A-2 053 757 (ROLLS-ROYCE LTD.) * Claims 1-4 * -----	15,16	

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

B 22 C 7/00
B 22 C 9/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	08-03-1983	GOLDSCHMIDT G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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